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1.01	RESERVED					
1.02	RESERVED					
1.03	RESERVED					
1.04	RESERVED					
1.05	Single Point Failures	Single point failures that prevent the ability to fully meet Mission success requirements shall be identified, and the risk associated with each shall be characterized, managed, and tracked.				
1.06	Resource Margins	System resource margins shall be evaluated in accordance with Table 1.06-1, with margin and contingency/reserve defined in the table, and illustrated in Figures 1.06-1 and 1.06-2. Table 1.06-2 is a schedule of recommended mass contingency or reserve by subsystem.				
1.07	End-to-End GN&C Phasing	All GN&C sensors and actuators shall undergo end-to- end phasing/polarity testing after spacecraft integration and shall have flight software mitigations to correct errors efficiently.				
1.08	End-to-End Testing	System end-to-end testing shall be performed using actual flight hardware and software, wherever practicable, and shall apply from input to instrument(s), through the spacecraft, transmitted to receiving antennas, and through the ground system - reconciled against what is physically achievable before launch, and consistent with associated mission risk.				
1.09	Test as You Fly	All GSFC missions shall follow a, "Test as You Fly (TYF) - Fly as You Test" approach, throughout all applicable lifecycles.				
1.10	RESERVED					

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1.11	Qualification of Heritage Flight Hardware	All heritage flight hardware shall be fully qualified and verified for use in its new application. This qualification shall take into consideration necessary design modifications, changes to expected environments, and differences in operational use.						
1.12	RESERVED							
1.13	RESERVED							
1.14	Mission Critical Telemetry and Command Capability	Continuous telemetry coverage shall be maintained during all mission-critical events. Mission-critical events shall be defined to include separation from the launch vehicle; power-up of major components or subsystems; deployment of mechanisms and/or mission-critical appendages; and all planned propulsive maneuvers required to establish mission orbit and/or achieve safe attitude. After separation from the launch vehicle, continuous command coverage shall be maintained during all following mission-critical events.						
1.15	RESERVED							
1.16	RESERVED							

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Rule No.	<u>Title</u>	<u>Principle</u>	Compliant (Yes = Y; No = N; TBD = T) [Note 1*]	Supporting Documentation [Note 2*]	Rationale [Note 3*]	Waiver Request ID & Status [Note 4*]	
1.17	Safe Hold Mode	All spacecraft shall have a power-positive control mode (Safe Hold) to be entered in spacecraft emergencies. Safe Hold Mode shall have the following characteristics: (1) its safety shall not be compromised by the same credible fault that led to Safe Hold activation; (2) it shall be as simple as practical, employing the minimum hardware set required to maintain a safe attitude; and (3) it shall require minimal ground intervention for safe operation.					
1.18	RESERVED						
1.19	Initial Thruster Firing Limitations	All initial thruster firings shall occur with real-time telemetry and command capability. If alternate actuators (e.g. reaction wheels) are present, the momentum induced by initial firings shall be within the alternate actuators' capability to execute safe recovery of the spacecraft.					
1.20	Manifold Joints of Hazardous Propellants	All joints in the propellant manifold between the propellant supply tank and the first isolation valve shall be NDE-verified welds.					
1.21	Overpressurization Protection in Liquid Propulsion Systems	The propulsion system design and operations shall preclude damage due to pressure surges ("water hammer"). (Note: See also rule 1.28 "Unintended Propellant Vapor Ignition.")					
1.22	Purging of Residual Test Fluids	Propulsion system design and the assembly & test plans shall preclude entrapment of test fluids that are reactive with wetted material or propellant.					
1.23	Spacecraft 'OFF' Command	In a redundant Spacecraft with no hardware failures, no single command shall result in Spacecraft "OFF." In a single string Spacecraft, or a redundant Spacecraft with a failure, no single command shall result in Spacecraft "OFF."					
1.24	Propulsion System Safety Electrical Disconnect	An electrical disconnect "plug" and/or set of restrictive commands shall be provided to preclude inadvertent operation of propulsion system components.					

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No.	<u>Title</u>		[Note 1*]	[Note 2*]	[Note 3 ⁴]	[Note 4*]
1.25	Redundant Systems	When redundant systems or functions are implemented for risk mitigation, the redundant components, or functional command paths, shall be independent, such that the failure of one component or command path does not affect the other component or command path. Critical single point failures due to electrical, thermal, mechanical and functional dependencies should be documented.				
1.26	Safety Inhibits & Fault Tolerance	If a system failure may lead to a Catastrophic Hazard, the system shall have three independent, verifiable inhibits (dual fault tolerant). If a system failure may lead to a Critical Hazard, the system shall have two independent, verifiable, inhibits (single fault tolerant). Hazards, which cannot be controlled by failure tolerance (e.g., structures, pressure vessels, lines, etc.), must be "Designed for Minimum Risk" (DFMR), and have separate, detailed safety requirements. Hazard controls related to these areas are extremely critical and warrant careful attention to the details of verification of compliance on the part of the developer. The external leakage of hazardous propellant is a Catastrophic Hazard. Dynamic seals (e.g. solenoid valves) shall be independently verified as close to propellant loading as possible. Static seals (i.e. crush gaskets, o-rings, etc) are recognized as non-verifiable at the system level. The integrity of these seals shall be controlled by process or procedures consistent with industry standards. Components where fault tolerance is not credible or practical (e.g., tanks, lines, etc.) shall use design for minimum risk instead.				
1.27	Propulsion System Overtemp Fuse	Flight fuses for wetted propulsion system components shall be selected such that overheating of propellant will not occur at the maximum current limit rating of the flight fuse. (Note: See also rule 2.06 "System Fusing Architecture.")				
1.28	Unintended Propellant Vapor Ignition	Propulsion system design and operations shall preclude ignition of propellants in the feed system.				

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NO.	<u>Title</u>		luore i 1	[Note 2]	[Note 5]	[Note 4*]	
1.29	RESERVED						
1.30	Controller Stability Margins	The Attitude Control System (ACS) shall have stability margins of at least 6db for rigid body stability with 30 degrees phase margin, and 12db of gain margin for flexible modes.					
1.31	Actuator Sizing Margins	The Attitude Control System (ACS) actuator sizing shall reflect specified allowances for mass properties growth.					
1.32	Thruster and Venting Impingement	Thruster or external venting plume impingement shall be analyzed and demonstrated to meet mission requirements.					
1.33	Polarity Checks of Critical Components	All hardware shall be verified by test or inspection for the proper polarity, orientation, and position of all components (sensors, switches, and mechanisms) for which these parameters affects performance.					
1.34	Closeout Photo Documentation of Key Assemblies	Projects shall produce closeout photographic documentation of all assemblies during the manufacturing process and of the final integrated configuration "as flown."					
1.35	Maturity of New Technologies	All technologies shall achieve a TRL 6 by PDR. Not applicable to technology demonstration opportunities.					
1.36	RESERVED						
1.37	Stowage Configuration	When a spacecraft is in its stowed (launch) configuration, it shall not obscure visibility of any attitude sensors required for acquisition, and it shall not block any antennas required for command and telemetry.					
1.38	RESERVED						
2.01	Flight Electronic Hardware Operating Time	One thousand (1000) hours of operating/power-on time shall be accumulated on all flight electronic hardware (including all redundant hardware) prior to launch, of which at least 200 hours shall be in vacuum. The last 350 hours of operating/power-on time shall be failure-free.					

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	EEE Parts	A EEE parts program shall be planned for and implemented for all flight missions for the purpose of					
2.02	Program for Flight Missions	part selection, de-rating, screening, and overall qualifications.					
	Radiation Hardness	A Radiation Hardness Assurance (RHA) Program shall be planned for and implemented for all flight missions					
2.03	Assurance	to verify component- and system-level radiation					
2.04	Program RESERVED	hardness by CDR.					
2.05	System Grounding	A system grounding design shall be developed and					
	Architecture System Fusing	documented for all missions. A system fusing architecture shall be developed and					
2.06	Architecture	documented for all missions, including the payloads.					
	End-to-End Test of Release	A release mechanism test for the flight deployable components shall be performed as an end-to-end					
2.07	Mechanism for Flight Deployables	system-level test under worst-case conditions and a realistic timeline					
2.08	RESERVED						
2.09	RESERVED						
2.10	RESERVED						
2.11	RESERVED						
2.12	Printed Circuit Board Coupon	All flight printed circuit boards (PCBs) shall be verified by coupon testing prior to assembly of components					
	Analysis	onto the boards.					
	Electrical	Mating of all flight connectors which cannot be verified via ground tests, shall be clearly labeled and keyed					
2.13	Connector Mating	uniquely, and mating of them shall be verified visually to					

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2.14	Protection of Avionics Enclosures External Connectors Against ESD	All avionics enclosures shall be protected from ESD. All external connectors must be fitted with shorting plus or appropriate caps during transportation between locations. Additionally, all test points and plugs must be capped or protected from discharge for flight.				
2.15	Flight and Ground Electrical Hardware	The use of pure tin, cadmium, and zinc plating in flight and ground electrical hardware shall be prohibited.				
2.16	RESERVED					
2.17	RESERVED					
2.18	Implementation of Redundancy	The implementation of redundant functions shall be accomplished in such a way that any credible single point failure anywhere in the system shall not result in unacceptable degradation of the redundant side. When cross-strapping, the design shall avoid routing of redundant signals through a single connector, relay or integrated circuit.				
2.19	RESERVED					
2.2	RESERVED					
2.21	RESERVED					
2.22	Corona Region Testing of High Voltage Equipment	Assemblies containing a High Voltage supply that is not tested through the Corona region shall undergo venting / outgassing analysis to determine when it is safe to turn on and operate after launch.				
3.01	Verification and Validation Program for Mission Software Systems	A thorough verification and validation process shall be applied to all mission software systems. This process shall trace customer/mission operations concepts and science requirements to implementation requirements and system design, and shall include requirements based testing of all mission elements, and end-to-end system operations scenario testing.				

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3.02	Elimination of Unnecessary and Unreachable Software	An analysis of unnecessary and/or unreachable code, as defined per Table 3.02-1, shall be performed on the intended flight load for launch. The analysis shall identify all instances (areas) of unnecessary/unreachable flight code, the general functionality associated with the code, the reason each is intended to be left within the flight load, and the justification (e.g. mitigating action) that explains why the included code does not provide a risk to the mission. The focus is on technical risk to the long-term mission, not cost.				
3.03	High Fidelity Interface Simulation Capabilities	A high fidelity software simulation capability for each external interface to FSW shall be provided in the FSW development/maintenance environments. Both nominal and anomalous data inputs to FSW shall be configurable in real-time using the procedure language of the FSW test workstation.				
3.04	Independent Software Testing	Software functional/requirements and comprehensive performance verification/validation testing shall be performed by qualified testers that are independent of the software designers and developers. NOTE: For small projects, members of the same development team can perform independent testing as long as the assigned testers have not been involved in any part of the design and development of the software components being tested.				
3.05	Flight / Ground System Test Capabilities	Access to flight system interface and functional capabilities, provided either by the spacecraft or by spacecraft simulators, shall be negotiated with all stakeholders, including the ground system and operations teams. Schedules and agreements should address the spacecraft and spacecraft simulators at all levels of fidelity.				

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3.06	Dedicated Engineering Test Unit (ETU) for Flight Software (FSW) Testing	An ETU flight data system testbed shall be dedicated to FSW teams specifically for FSW development and test. Such ETUs are supplemented by external interface simulators as specified in Rule 3.03 (High Fidelity Interface Simulation Capabilities). Hardware and I&T teams shall not plan to use the FSW ETUs for their critical path schedule. The number of flight data system testbed units shall be sufficient to support the FSW development schedule and the overall mission schedule.					
3.07	Flight Software Margins	Flight software resource margins shall be maintained in accordance with Table 3.07-1 and presented at Key Decision Point (KDP) milestone reviews.					
3.08	RESERVED						
3.09	RESERVED						
3.10	Flight Operations Preparations and Team Development	Experienced operations personnel shall participate as early as possible during mission development, preferably during the mission operations concept phase and the development of specifications for the spacecraft and/or instruments which impact operations. To prepare and train the FOT, they shall participate in flight operations readiness tests that are specified in Table 3.10. Note that these serve as guidelines and are not intended to be prescriptive.					
3.11	Long Duration and Failure Free System Level Test of Flight and Ground System Software	Ground test of the fully integrated FSW and ground system shall include demonstration of error free operations-like scenarios over an extended time period. The minimum duration of uninterrupted FSW system-level test (on the highest fidelity FSW testbed) and ground system operations is 72 hours for Class A and B missions; 48 hours for Class C missions; and, 36 hours for Class D missions, respectively.					
3.12	RESERVED						

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No.	<u>Title</u>	<u>глисцие</u>	[Note 1*]	[Note 2*]	[Note 3*]	[Note 4*]	
3.13	Maintenance of Mission Critical Components	The updating of mission critical components during the mission operations phase (including any combination of hardware platforms, hardware devices, and software code) shall not compromise the capability of the system to meet mission requirements. Missions shall provide sufficient quantities of flight and ground resources to allow development, test, and operations activities to be conducted without compromising mission availability requirements.					
3.14	Command Procedure Changes	Command procedures and/or scripts, and mission databases (onboard and ground) shall be controlled (treated with the same rigor as changes to flight critical software). This includes formal configuration management, peer review by knowledgeable technical personnel, and full verification with up-to-date simulations wherever possible. (Routine command loads to perform nominal operations may require less test rigor based on experience of senior engineers.)					
3.15	RESERVED						
4.01	RESERVED						
4.02	RESERVED						
4.03	Factors of Safety for Structural Analysis and Design, and Mechanical Test Factors & Durations	Structural analysis and design factors of safety shall apply to all systems in accordance with GEVS Section 2.2.5. The project shall employ the mechanical test factors and durations in accordance with GEVS Section 2.2.4.					
4.04	RESERVED						
4.05	RESERVED						

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4.06	Validation of Thermal Coatings Properties	All thermal analysis shall employ thermal coatings properties validated to be accurate for materials and mission flight parameters over the lifecycle of the mission.				
4.07	Solder Joint Intermetallics Mitigation	All materials at a solder joint shall be selected to avoid the formation of potentially destructive intermetallic compounds.				
4.08	Space Environment Effects on Material Selection	Thorough evaluation of the environmental effects of the trajectory paths/orbits shall be assessed for the impact on materials selection and design.				
4.09	RESERVED					
4.10	Minimum Workmanship	All electrical, electronic, and electro-mechanical components shall be subjected to minimum workmanship test levels as specified in GEVS Section 2.4.2.5.				
4.11	Test In Flight Configuration	Mechanical environmental testing (sine, random, & acoustic, shock, etc.) of flight hardware shall be performed with the test article in the flight like configuration. Mechanisms are configured for flight, and the flight or flight like blankets and harness shall be present for test.				
4.12	Structural Proof Testing	Primary and secondary structures fabricated from nonmetallic composites, beryllium, or containing bonded joints or bonded inserts shall be proof tested in accordance with GEVS-SE Section 2.4.1.4.1.				
4.13	RESERVED					
4.14	Structural and Mechanical Test Verification	Structural and Mechanical Test Verification program shall comply with GEVS-Table 2.4-1, Structural and Mechanical Verification Test Requirements.				

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4.15	Torque Margin	The Torque Margin (TM) requirement defined in GEVS section 2.4.5.3 shall apply to all mechanical functions, those driven by motors as well as springs, etc. at beginning of life (BOL). End of Life (EOL) mechanism performance shall be determined by life testing, and/or by analysis; however, all torque increases due to life test results and/or analysis shall be included in the final TM calculation and verification. Margins shall include all flight drive electronics effects and limitations.					
4.16	RESERVED						
4.17	RESERVED						
4.18	Deployment and Articulation Verification	All flight deployables, movable appendages, and mechanisms shall demonstrate full range of motion and articulation under worst-case conditions prior to flight.					
4.19	RESERVED						
4.20	Fastener Locking	All threaded fasteners shall employ a locking feature.					
4.21	Brush-type Motor Use Avoidance	Designs shall avoid brush-type motors for critical applications with very low relative humidity, or vacuum operations. Intentionally excluded from this rule are contacting sensory and signal power transfer devices such as potentiometers and electrical contact ring assemblies (slip rings, roll rings), etc.					
4.22	Precision Component Assembly	When precise location of a component is required, the design shall use a stable, positive location system (not relying on friction) as the primary means of attachment.					
4.23	Life Test	A life test shall be conducted, within representative operational environments, to at least 2x expected life for all repetitive motion devices with a goal of completing 1x expected life by CDR.					

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No.	<u>Title</u>		[Note 1*]	[Note 2"]	[Note 3*]	[Note 4*]					
4.24	Mechanical Clearance Verification	Verification of mechanical clearances and margins (e.g. potential reduced clearances after blanket expansion) shall be performed on the final as-built hardware.									
4.25	Thermal Design Margins	Thermal design shall provide adequate margin between stacked worst-case flight predictions and component allowable flight temperature limits per GEVS 2.6 and 545-PG-8700.2.1A. Note: This applies to normal operations and planned contingency modes. This does not apply to cryogenic systems.									
4.26	RESERVED										
4.27	Test Temperature Margins	Components and systems shall be tested beyond allowable flight temperature limits, to proto-flight or acceptance test levels as appropriate as specified in GEVS section 2.6, which specifies margins for passively and actively controlled hardware. Note that at levels of assembly above component, full specified margins may not always be achievable for all components due to test setup limitations; in these cases, the expected test levels shall be approved by the GSFC Project, and shall be presented at the earliest possible formal review, no later than PER.									
4.28	Thermal Design Verification	All subsystems/systems having a thermal design with identifiable thermal design margins shall be subject to a Thermal Balance Test at the appropriate assembly level per GEVS Section 2.6.									
4.29	Thermal-Vacuum	All systems flying in unpressurized areas shall have been subjected to a minimum of eight (8) thermal-vacuum test cycles prior to installation on a spacecraft. For an instrument, a minimum of four (4) of these eight (8) Thermal Vacuum cycles shall be performed at the instrument level of assembly.									
5.01	RESERVED										
5.02	RESERVED										
5.03	RESERVED										

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5.04		Active RF components, such as radars, shall be designed and tested for immunity to multipaction.									
5.05		Fluid systems GSE used to pressurize flight systems shall be compliant with the fault tolerance requirements of Rule 1.26.									
5.06	Characterization	Flight instruments and their components shall be characterized for performance over their expected operating temperature range.									
5.07	RESERVED										
5.08		All flight laser development shall include an approved laser-specific Contamination Control Plan (CCP).									
5.09	Cryogenic Pressure Relief	Stored cryogen systems (and related GSE) shall be compliant with the fault tolerance requirements of Rule 1.26.									
*Notes											
1. Include a completed compliance assessment per GPR 8070.4, Section 2.0.											
		elevant documentation for each non-compliance.									
3. Supply comments conveying the rationale for the project's assessment of each non-compliance and related future intent (i.e., waiver request, redesign to compliance, etc.).											

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